High Lift Prediction Workshop 5

Kick-Off Meeting

3/21/2023 – some modifications for consistency on 4/25/2023

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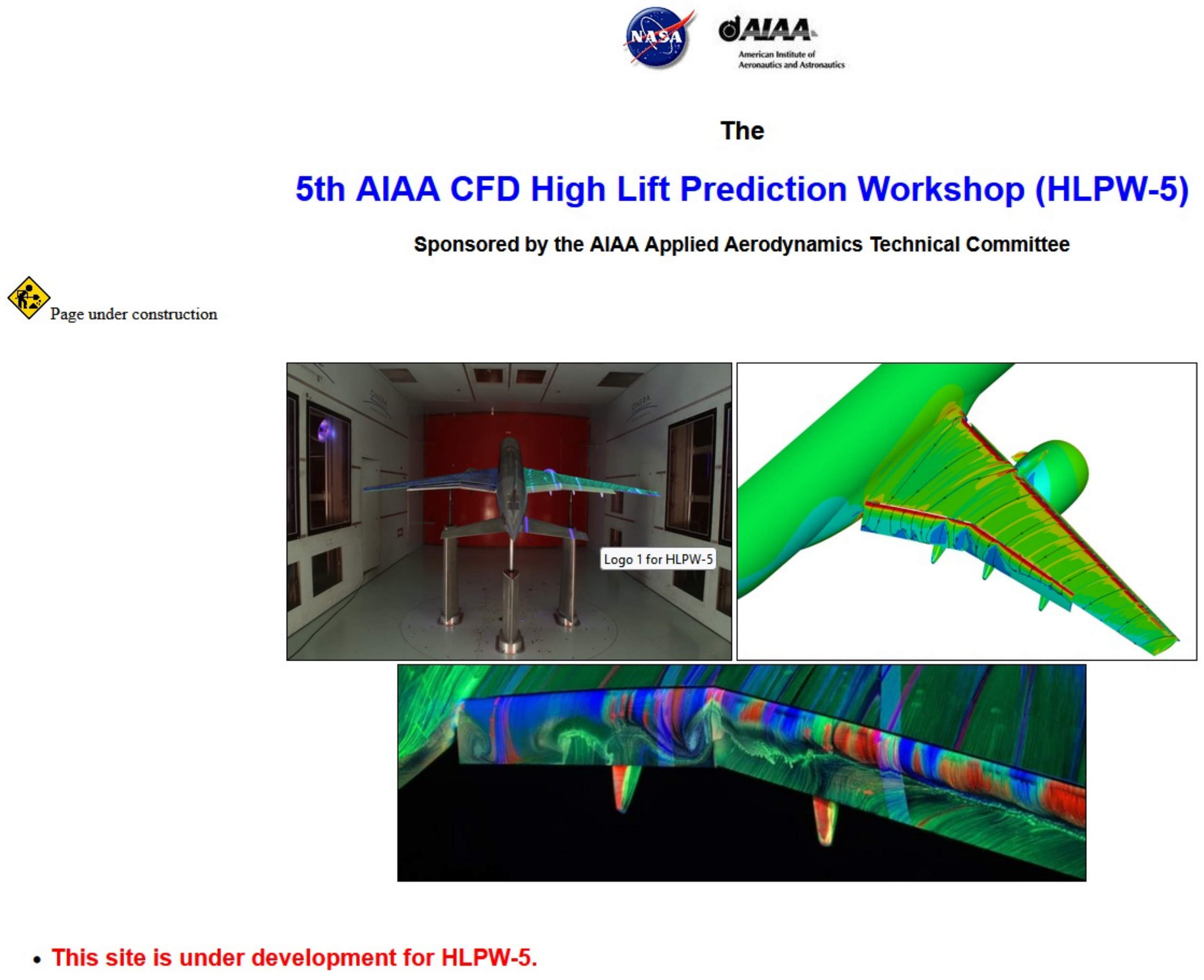
Agenda

- Website
- Schedule
- Test cases
- Geometry
- Technology Focus Groups (TFGs)
- To Do

HLPW-5 Website

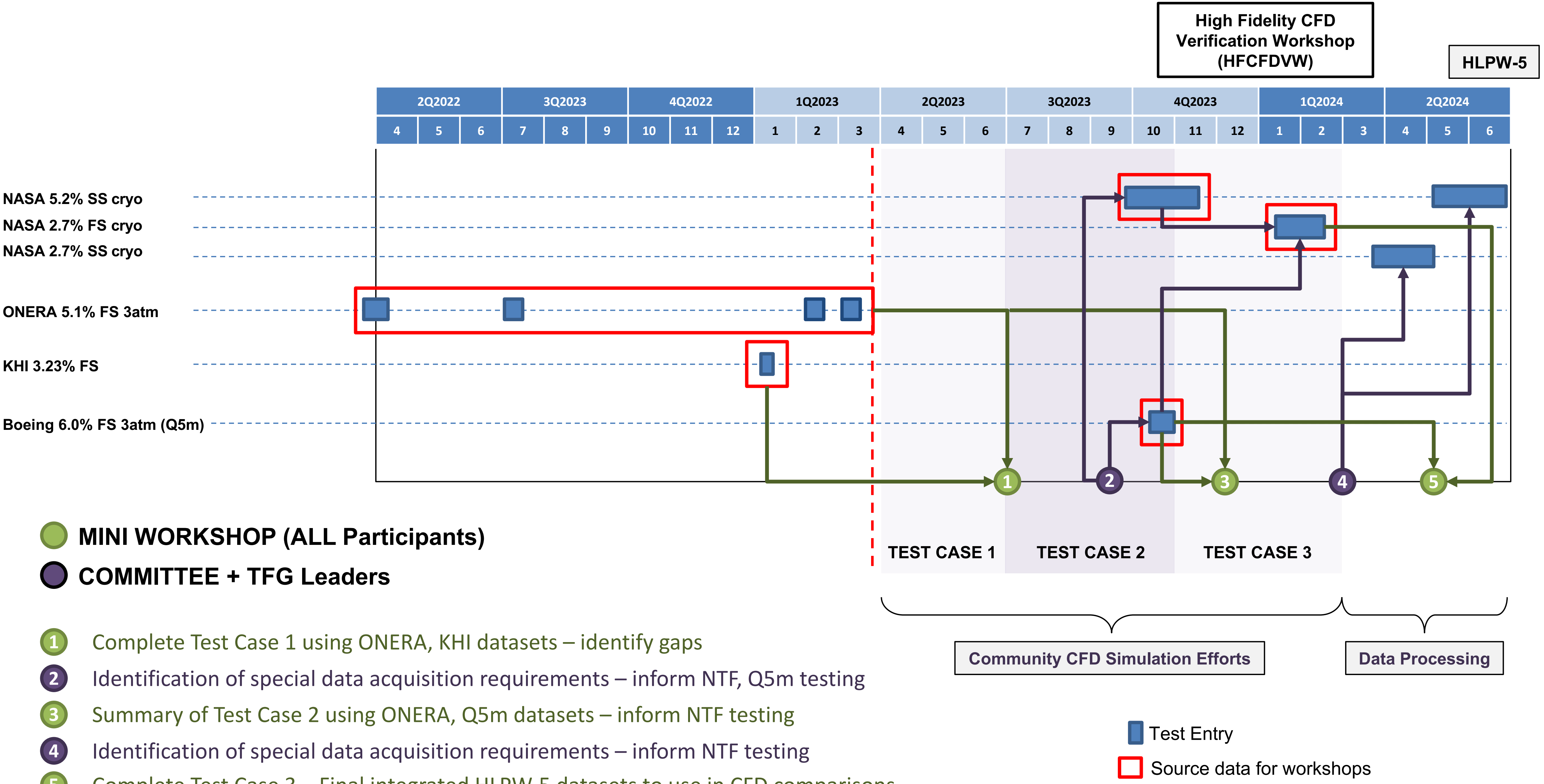
https://hiliftpw.larc.nasa.gov

- Contains key information about HLPW-5
- Points to previous workshops (e.g. HLPW-4)
- Points to CRM-HL related information
- Place for interested participants to sign up to be on the mailing list
- Current test case document uploaded



HLPW-5 Schedule

20 March 2023



MINI WORKSHOP (ALL Participants)

COMMITTEE + TFG Leaders

1. Complete Test Case 1 using ONERA, KHI datasets – identify gaps
2. Identification of special data acquisition requirements – inform NTF, Q5m testing
3. Summary of Test Case 2 using ONERA, Q5m datasets – inform NTF testing
4. Identification of special data acquisition requirements – inform NTF testing
5. Complete Test Case 3 – Final integrated HLPW-5 datasets to use in CFD comparisons

Test Case 1 – CRM-HL Wing-Body Verification

The verification problem for this workshop is based on the simplified CRM-HL Wing Body (CRM-HL-WB) configuration. The verification problem for this test case will be the same as the one initially introduced and utilized for the **High Fidelity CFD Verification Workshop (HFCFDVW),** planned for SciTech 2024. The target characteristics of this study are grid convergence of lift, drag, and moment coefficients (HFCFDVW does not require moment coefficient, but we require it here).

Geometry

- CRM-HL wing/body* (CRM-HL-WB)

Experimental Data

- None (for code-to-code Verification)

Computational Domain

- Rectangular cuboid computational domain with dimensions $-65{,}000 \leq x \leq 65{,}000$, $0 \leq y \leq 65{,}000$, $-65{,}000 \leq z \leq 65{,}000$
- Symmetry at y=0

Run Conditions

Mach Number	0.20
Chord Reynolds Number	5.6×10^6
Angle of Attack	11°
Reference Static Temperature	521 °R

Sample Key Questions

- Are RANS solvers able to demonstrate convergence to the same solution for a given turbulence model in grid refinement using families of fixed and adapted grids?
- For Non-RANS solvers, what is the most consistent approach to grid families that can demonstrate a trend towards grid independence on this problem?
- Is there enough consistency amongst non-RANS approaches that there is reasonable agreement on a grid independent solution?
- Does the ensemble of answers amongst modelling approaches compared to the experimental free air corrected data tell us anything useful about uncertainty?

Details

- Geometry is provided in full-scale inches
- When using a dimensional code, it is recommended to adjust viscosity to a non-physical value to match requested Reynolds number
- SA-neg-QCR2000-R is highly recommended, run fully turbulent (for RANS solvers)
  - Strongly recommended that RANS participants utilize grids from Verification Workshop, but alternate gridding strategies are encouraged, if appropriate
- Participants using non-RANS solvers are encouraged to demonstrate grid convergence on this problem using multiple grid levels along with their best practice solver settings, looking at convergence of the lift, drag, and moment coefficients. The gridding requirements in this section are purposefully left vague. Discussions within TFGs are expected to provide further guidance on how to best family grid sequences for these approaches.

* Reference configuration

Test Case Released: **21 March 2023**
Data due by: **19 June 2023**

Test Case 2 – Configuration Build-Up

Flow solutions are requested to assess the ability of CFD to predict the effect of varying geometric fidelity through component build-up to help isolate specific types of flow physics associated with high-lift aerodynamics. Geometry will be provided for four separate geometric configurations of increasing levels of complexity, with simulations to be performed free-air and compared to fully corrected data.

Geometry

- Wing/body (CRM–HL–WBHV) *
- Wing-Body-Slat (ONERA_LRM–WBSHV) †
- Wing-Body-Slat-Flaps (ONERA_LRM–WBSFHV) †
- Wing-Body-Slat-Flaps-Nacelle (ONERA_LRM–LDG-HV) †

Experimental Data

- QinetiQ 5-metre, ONERA F1

Computational Domain

- Symmetry at y=0

Run Conditions

Mach Number	0.20
Chord Reynolds Number	5.4×10^6 (WBHV), 5.9×10^6 (all others)
Angles of Attack	6-8 alphas (TBD)
Reference Static Temperature	518.67 °R
Reference Static Pressure	14.696 psi

Sample Key Questions

- Does the consistency in integrated forces/moments from CFD simulations improve when modeling geometrically simpler HL configurations?
  - Are there unique CFD modeling requirements (e.g. mesh, solver, etc.) for an unprotected Leading Edge (LE)?
  - How does the additional of the LE device (slat) effect CFD modeling, both in terms of accuracy and consistency?
  - How does the additional of the TE device (flap) effect CFD modeling, both in terms of accuracy and consistency?
  - How does the additional of the pylon/nacelle effect CFD modeling, both in terms of accuracy and consistency?
- If accuracy falls off due to the presence of a single component, can better modeling approaches be established to improve the predictions?

Details

- Geometry is provided in full-scale inches
- When using a dimensional code, it is recommended to adjust viscosity to a non-physical value to match requested Reynolds number
- All simulations are run Free-Air, with no tunnel or support systems included

Optional

- Several elements of the computational modeling can be investigated to explore sensitivity of solutions. These include, but are not limited to:
  - Use of specific wind tunnel model geometry associated with a particular test campaign
  - Use of static tunnel aeroelastic deformations
  - Performing in-tunnel simulations (either with the test section only, or including expansion/contraction sections)
  - Physical tripping or transition modelling
  - Systematic mesh refinement

* Reference configuration (used for Boeing model)

† As-designed ONERA 1/19.5 scale model

Test Case Released: **1 June 2023**
Data due by: **23 October 2023**

Test Case 3 – Reynolds Number Study

Flow solutions are requested to assess the capability of CFD to predict the effects of increasing Reynolds number on the aerodynamic performance of the CRM-HL in the reference landing configuration. Solutions are requested across specified angles of attack, at four different Reynolds numbers, and will be compared to fully corrected data obtained from several different facilities.

Geometry

- Wing-Body-Slat-Flaps-Nacelle (NASA_5.2%–LDG) *

Experimental Data

- KHI LSWT, ONERA F1, NASA NTF, QinetiQ 5-metre

Computational Domain

- Symmetry at y=0

Run Conditions

Mach Number	0.20
Chord Reynolds Number	1.05m, 5.49m (TBV), 16m (TBV), 30m (TBV)
Angles of Attack	6-10 alphas (TBD)
Reference Static Temperature	518.67 °R
Reference Static Pressure	14.696 psi

Sample Key Questions

- Are there unique gridding requirements for a particular Reynolds number?
- Does CFD accurately capture Reynolds number trends in integrated forces and moments up to flight scale?
- Does CFD accurately capture trends in aerodynamic flow separation vs Reynolds number?
- How important is aeroelastic modeling for accurate predictions at higher Reynolds numbers?
- Is running simulations in free-air adequate to understand trends and increments, or is running in-tunnel simulations, compared against uncorrected data, required?

Details

- Geometry is provided in full-scale inches
- When using a dimensional code, it is recommended to adjust viscosity to a non-physical value to match requested Reynolds number
- All simulations are run Free-Air, with no tunnel or support systems included

Optional

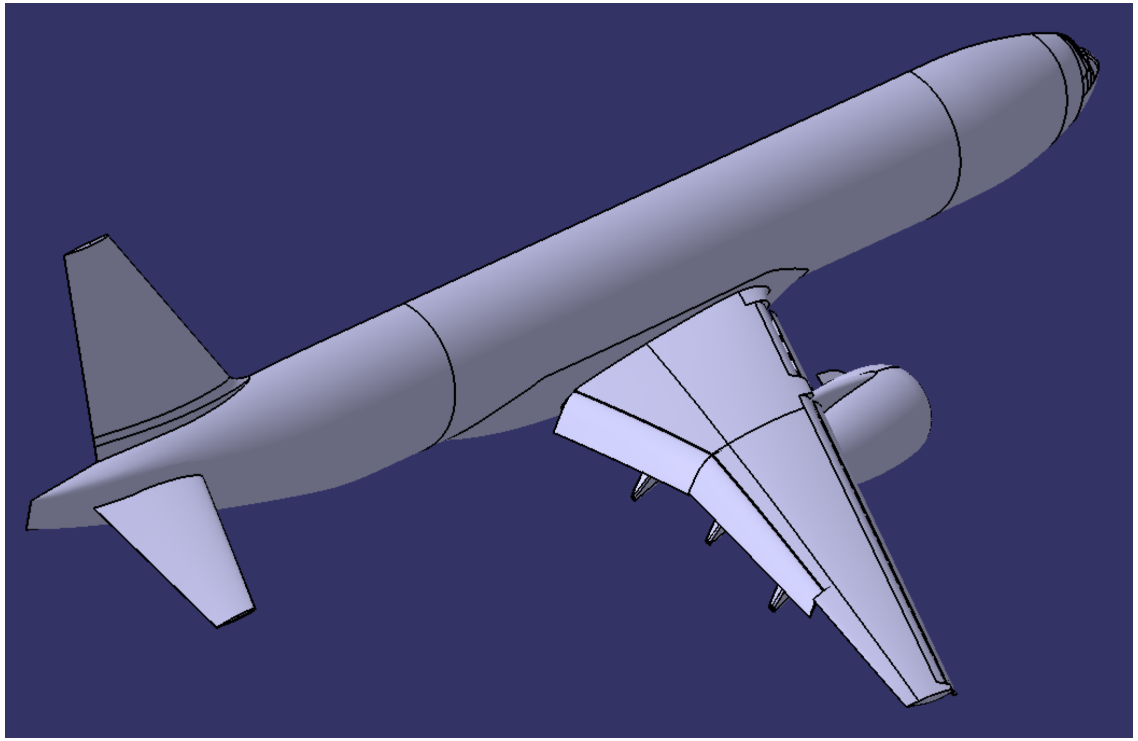
- Several elements of the computational modeling can be investigated to explore sensitivity of solutions. These include, but are not limited to:
  - Use of specific wind tunnel model geometry associated with a particular test campaign
  - Use of static tunnel aeroelastic deformations
  - Performing in-tunnel simulations (either with the test section only, or including expansion/contraction sections)
  - Physical tripping or transition modelling
  - Systematic mesh refinement

* As-designed NASA 5.2% scale model

Test Case Released: **2 October 2023**
Data due by: **19 February 2024**

Geometry

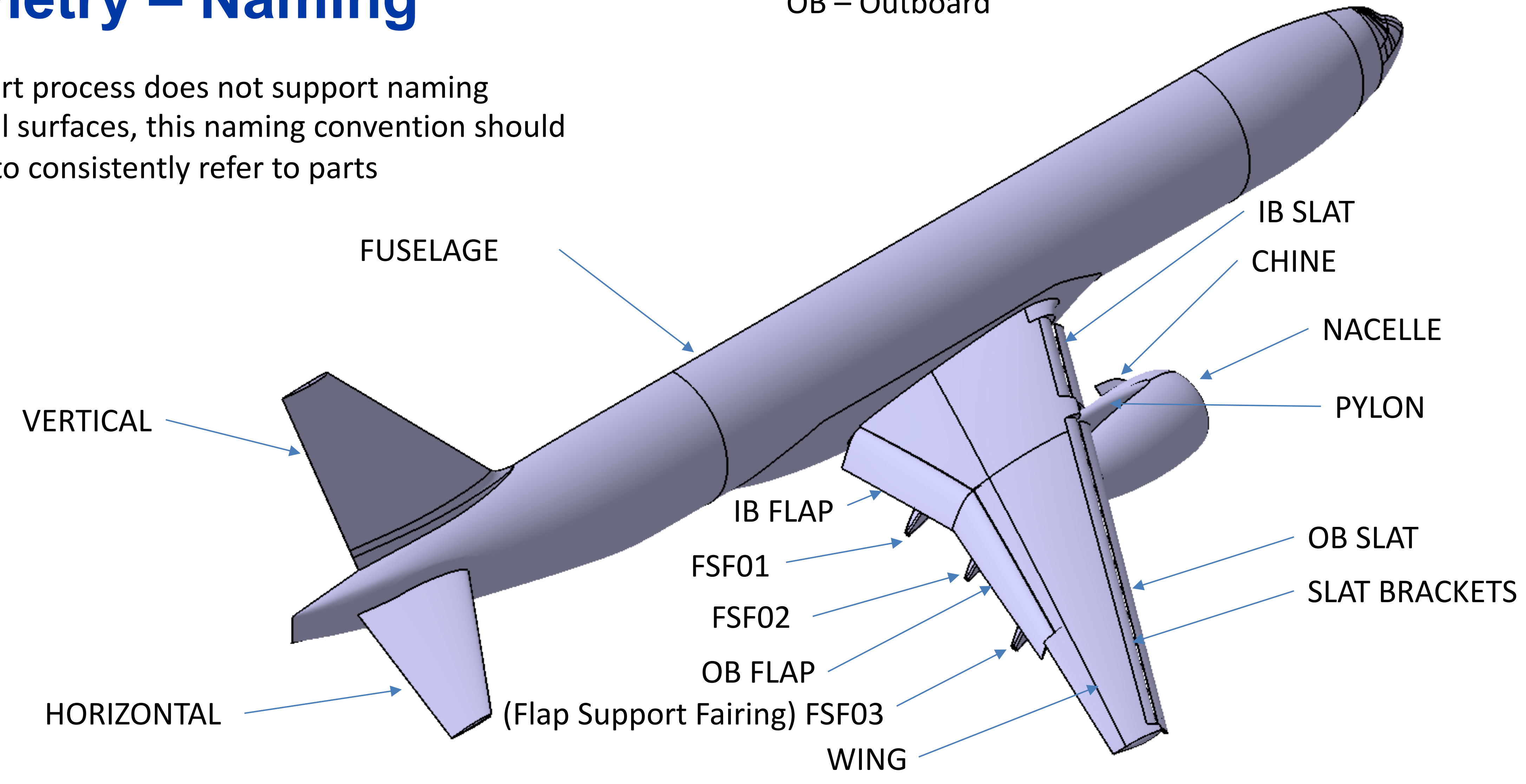
- Geometry for each test case is consistently assembled as a solid in CATIA, and exported as a solid STEP file, and a surface-only IGES
- It is recommended to work with the STEP where possible
- Efforts have been made to ensure a high quality definition is provided for each test case, and each have been tested across multiple CAD packages, however history shows we'll still run into various issues – please contact me!
- In general, the end user should not be creating geometry other than the domain
- All models are provided in full-scale inches



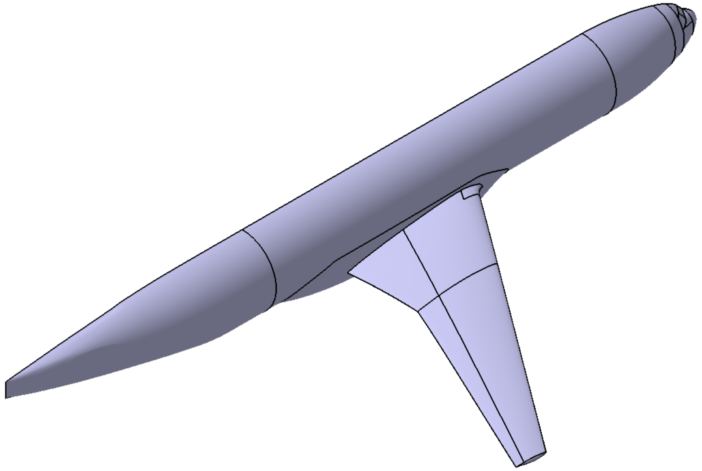
Geometry – Naming

IB – Inboard
OB – Outboard

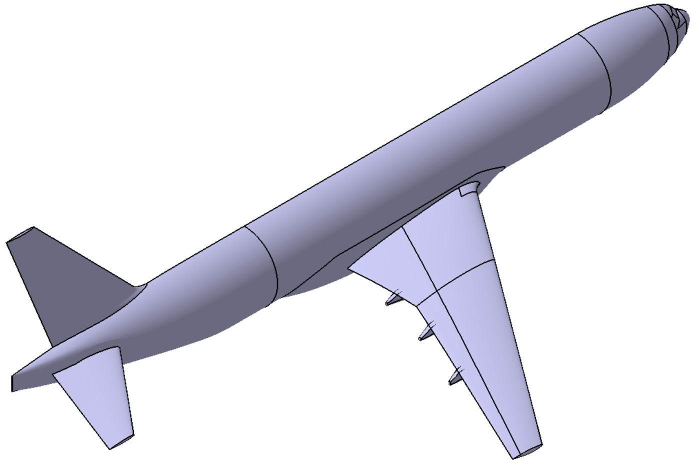
The export process does not support naming individual surfaces, this naming convention should be used to consistently refer to parts



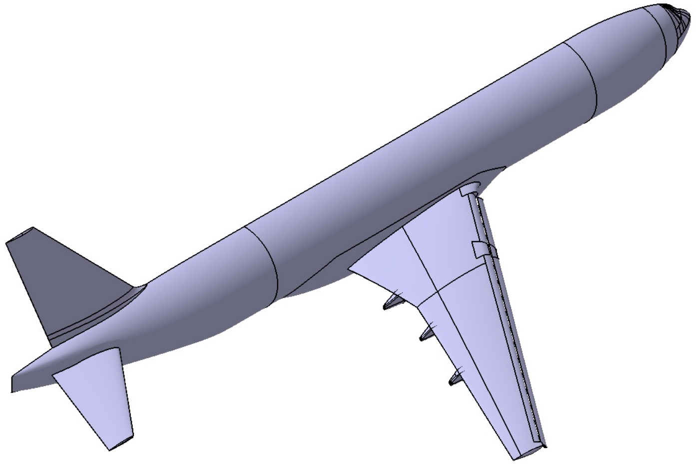
Case Specific Geometry



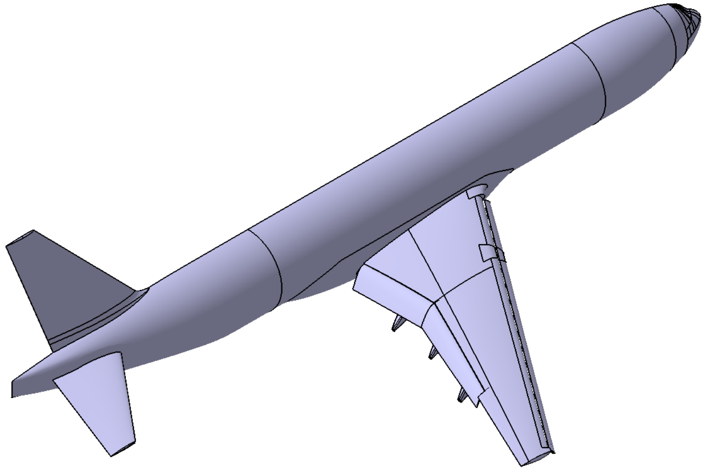
Case 1: CRM-HL-WB



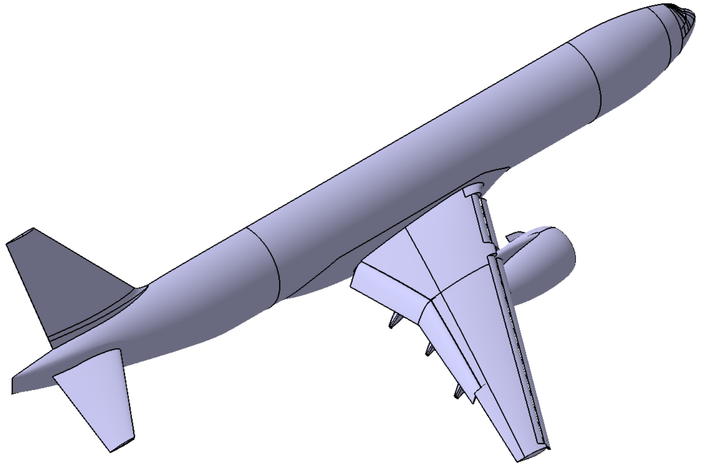
Case 2.1: CRM-HL-WBHV



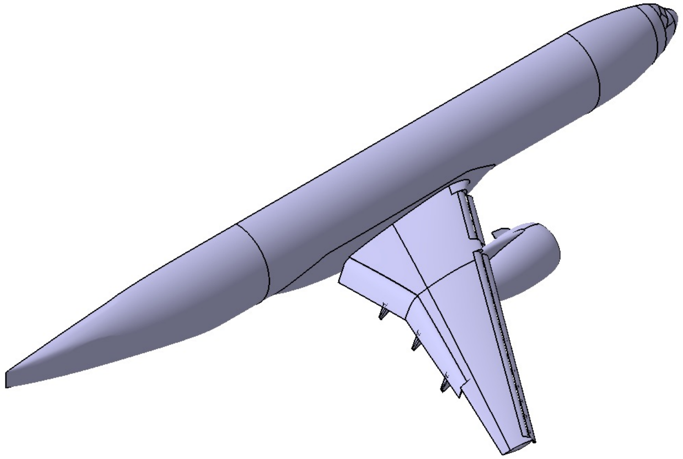
Case 2.2: ONERA_LRM-WBSHV



Case 2.3: ONERA_LRM-WBSFHV



Case 2.4: ONERA_LRM-LDG-HV



Case 3: NASA_5.2%-LDG

Technology Focus Groups (TFGs)

- Introduced during HLPW-4
  - Borne from community feedback from previous workshops that "learnings have stagnated"
  - Recognizes that several new CFD technologies are becoming available and viable
- Objective: **Accelerate learning through expert-driven, focused CFD validation activities**
- Outcomes tied directly to answering **key technical questions** (developed by TFGs)
- Teams **self-organize and operate independently** to address key questions
- TFG leader **organizes regular meetings** to discuss technical results, and **leads the development of data and presentation materials** for workshop events.
- Contact TFG leader to be included on meeting invitations

TFG	Leader (s)	Email
Fixed Grid RANS	Boris Diskin	boris.diskin@nianet.org
Adaptive Meshing	Mike Park	mikepark@luminarycloud.com
High-Order Methods	Marshall Galbraith Steve Karman	galbramc@mit.edu karmansl@ornl.gov
Hybrid RANS/LES	Neil Ashton	neashton@amazon.co.uk
WMLES	Cetin Kiris	cetin@volcanoplatforms.com